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as the work of the mind, but in this respect his doctrine differs not at all from the doctrine of relations maintained by many transcendentalists. Are we not warranted in asking whether Mr. Russell's transcendentalism advances the problem of relations beyond the point at which Locke and Kant left it?

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THE FITNESS OF THE ENVIRONMENT FOR THE CONTINUITY OF CONSCIOUSNESS

PROFESSOR HENDERSON, in his book from which the first part of the above title is borrowed. has demonstrated with much ingenuity how it is that our terrestrial surroundings are just fit for the conservation of animal life. The atmosphere is of the proper density and mixture, the ocean of the precise temperature and neutrality, and the basic elements of organic compounds of exactly the required valence to yield the entire plexus of biologic life that now prevails on the globe.

The question I wish to raise is: What must be the nature of the environment which should secure to us the continuity of the thought process? Two things are necessary for the continuity of consciousness: first, awareness of the present, and second, recollection of the past. Or, to be more precise, the interlocking of the present with the past. Our consciousness of the future is really a function of our consciousness of the past. A being can look ahead only as far as backward, and no farther. The child does not know what to-morrow is because he seldom remembers his yesterday, and for the same reason the future of the aged man becomes narrow and circumscribed as a result of declining memory. What must be the nature of the environment, then, which should yield the richest and most tenacious interlocking of the present with the past?

There are, to begin with, two kinds of environments which stand in antithesis to each other. One is the absolutely homogeneous, the other the absolutely heterogeneous. By homogeneous environment I mean the knd in which there are no two things that are different. Indeed, within it there are no things, but all is one thing. It is the kind of environment that might be made to exist for a gold-fish in a glass jar. Conceive the water of the vessel to be of constant temperature and salinity; conceive the food of the animal to be uniformly dissolved throughout the water; conceive the walls of the jar to extend farther back in space than the animal can traverse within its natural life-time; finally, conceive all vibratory disturbances such as motion, light, and sound either constant or eliminated altogether. It is obvious that the experience of an animal in such an environment would not be rich. It would be the same experience every instant. After the first pulse of life nothing new would enter its consciousness. The last chapter of that animal's life would be written with the first stroke of the pen. It would always be living in the past, though possibly it would not know it. Its consciousness would center around a single pulse or point of experience from which it could never get away. As such a consciousness would necessarily be of zero dimension, it follows that there could be no continuity of the thought process in a completely homogeneous environment.

So let us turn to the absolutely heterogeneous *milieu.* By heterogeneous environment I mean the kind in which not only no two things are the same, but in which no two things bear the slightest resemblance to each other; indeed, it is the kind of environment in which not even the same thing persists in a uniform state for an appreciable length of time. Such surroundings need not necessarily be destructive to the biologic process. Suppose air changed to water, water to earth, and earth to air, at irregular and unexpected intervals, it is conceivable that such an animal as the kingfisher, or some other creature that can walk, fly, and swim with equal ease would be well able to withstand such hurly-burly. Conceive everything on the earth undergoing a perceptible change. All things do change, it is true, but, apart from the coarser spatial movements, we experience things and not their change. But suppose conditions were such that the tree you saw yesterday were replaced by a flower to-morrow, your dog, like Faust's, became a devil, and your table a typewriter. And you, like Dr. Faust, were quite able to adjust yourself to each new situation, because the situation itself would modify you in such a way as to enable you to survive the eternal round of change. What would be the nature of consciousness then? A million new experiences, not one abiding, not one recurring, not one resembling any of the myriads that have preceded it! Obviously an organism living in such an environment would have a manifold of impressions. Its consciousness of the present would extend to the *n*th power. Would it have a sense of the past? If not, then the heterogeneous environment would be no better than the homogeneous one. With respect to the latter we said that consciousness would center round a single point of experience with no possibility of expansion; hence no continuity. With respect to the former, consciousness would be diffused over a wide range of unrelated experiences with no possibility of connection; hence, also, no continuity. What, then, must be the nature of the environment which should afford us the greatest variety of experiences and at the same time preserve and awaken the richest memory of the past? Inasmuch as the former depends on diversity and the latter on uniformity or similarity of impressions, we have before us a problem in *maxima* and *minima.*

Experiments on the process of recognition within the visual realm, which I have conducted for several years, divulged a set of facts that seem to throw some light on the problem before us. My task was to find out the relation between recognition and degree of similarity of *meaningful* objects. That is to say, it was an experiment on ideational recognition and discrimination with graded stimuli, as distinct from sensory discrimination, which characterized all previous experiments where quantified stimuli were used.

My material consisted of a large number of picture post-cards grouped in pairs on the basis of similarity. The amount of similarity between the members of each pair was determined in terms of percentage, by 15 competent men—students and instructors in the Harvard graduate school of arts and sciences. Two cards that were totally dissimilar—one representing a red rose, the other a gray church outlined against a blue sky—were given the arbitrary value of 0 per cent. *S* (*S* = similarity). Two other cards that were identical constituted the 100 per cent. *S* end of the scale. Between these two extremes my 15 judges were advised to locate the other pairs of picture post-cards, in terms of ten or multiples of ten. By taking the average of the 15 judgments rendered for each pair of cards, I obtained their amount of similarity.[1] The reliability of this average was, of course, determined by the mean variation. Yet the mean variation differed with every degree of similarity, and this is due to the fact that it was a function of the range of judgment, as it should be. That is to say, cards that were rated as 40 per cent. *S* had a larger M. V. than those that fell within the 0 per cent. or 80 per cent. unit of the similarity scale. The reason is that the cards of 40 per cent. *S* afforded a wider range of judgment—a range that varied between 0 per cent. and 90 per cent.—than did the cards which fell into either of these last units. The following table gives the scale of similarity, the average M. V. corresponding to each unit of the scale, and the number of pairs of cards that entered into the construction of each unit.

TABLE I

Per cent. *S.*	0	10	20	30	40	50	60	70	80	90	100
Av. M. V.	0	..	12	12	13	12	11	9	6	..	0
Pairs	50	0	15	25	43	57	78	61	28	0	50

The largest M. V. we have is 13 corresponding to 40 per cent. *S.* If we bear in mind that the range of this judgment was 80, possibly

[1] A like method was used by Professor Thorndike in the construction of his writing scale.

90 units, we shall see that our largest M. V. is 16 per cent. possibly only 14 per cent. of the total range. We may conclude, then, that these judgments were fairly representative of the actual similarity that existed in the cards. To avoid any doubts I might further add that the judgments were rendered by each individual separately, *i. e.*, without any suggestion or advice from any one. The only instruction I gave to my men was to judge on the basis of their first impression, not to debate too much. As all the cards were spread out before them, as well as the 0 and 100 per cent. norms, the subjects were allowed to look over the entire display so as to get an idea of the relative degrees of similarity before they began the actual rating.

With the cards thus standardized and properly marked on the back, I proceeded to the experiment on recognition and discrimination. The method was this: One of the standardized cards, marked *A* (the normal), was exposed among a definite number of other picture post-cards, called fillers, for a definite time, say 5 seconds. An interval of 20 seconds then intervened, during which time the subject, separated from the experimenter by a screen, was required to retain as much of the material he had just observed as he possibly could. In the meanwhile, card *A* was removed and the variable, *B*, substituted. At the end of this interval the whole group was exposed once more for 5 seconds, and the subject was required to say whether all the cards of the second exposure were identical with those of the first, or whether one of them was changed, and, if so, which one. Not only were my subjects obliged to indicate the card which they thought was new, but they also had to name or to describe the card which it had displaced.

For this experiment I had ten subjects, all trained psychologists. Of course none of them had seen the cards before. After each pair of exposures new cards were used to construct the environment. A critical pair of cards was never used in more than one experiment—*i. e.*, never used twice on the same subject. The reason for exposing the critical card among a group of others was to test the process of recognition under conditions corresponding to life, namely, with distributed attention.[2] It is clear that where I made no change at all I had the condition of 100 per cent. *S*. Without going into details as to how I manipulated the various factors involved so as to obtain those conditions which, with the greatest number of cards exposed for the shortest time possible, would yield 100 per cent. correct discriminations when a card of 0 per cent. *S* was substituted and 100

[2] This experiment was carried on in the Harvard psychological laboratory under the direction of Professor Münsterberg, to whom my thanks are due for many valuable suggestions. A more extended report of the investigation will be published before long in the *Psychological Review Monographs*.

per cent. correct recognitions when a card of 100 per cent. *S* was substituted (*i. e.*, when no substitution was made at all), suffice it to say that I finally succeeded in finding the ideal combination of size and length of exposure which gave me these results within reasonable limits.

What we are concerned with chiefly is this: (1) What is the per cent. discrimination corresponding to each degree of similarity? This will give us an index of the extent to which consciousness of new experience is impoverished or enriched by increasing or decreasing similarity, *i. e.*, uniformity of environment. For it is obvious that the higher the degree of similarity the lower the per cent. discrimination—that is, the fewer the experiences of newness; and *vice versa*. (2) What is the per cent. recall occasioned by the discriminations corresponding to the various degrees of similarity? Inasmuch as this recall, besides depending in part on immediate memory, would depend in the main on association by similarity, it follows that the greater the resemblance of the new experience to the old, the more often would it revive the memory of the old. Here we have an index of the extent to which increasing or decreasing similarity of stimuli—*i. e.*, of environment—tends to revive or inhibit memory of past experiences. Or, in other words, tends to connect the past with the present.

Now inasmuch as discrimination (*D*), is a function of dissimilarity; and recall, (*R*), a function of similarity, the highest value of $D \times R$ which we can obtain for any value of *S*, will therefore be an index of that sort of environment which is most ideal for the continuity of consciousness—that is, for the interlocking of the greatest variety of present experiences with the richest memory of past. Table II. contains the results from which we derive our answer. The number of judgments that entered into each determination may be obtained by multiplying the number of pairs of cards which entered into the construction of each unit (see Table I.) by 10. The first horizontal line gives the degree of similarity; the second the corresponding per cent. discrimination, or judgments of *new* when a substitution was made; the third percentage of times that the discovery of the new card succeeded in reviving the memory of the old; and the fourth gives the product of *D* and *R* to two figures.

TABLE II

Per cent. *S*.	0	25	35	45	55	65	75	80	85	100
Per cent. *D*.	100	92	87	77	67	55	45	34	21	0
Per cent. *R*.	61	93	95	95	93	91	94	?	?	..
$D \times R$	61	*85*	*82*	73	62	50	42	..	..	..

From the above figures we notice the following facts: When the stimuli are totally unlike—*i. e.*, possess zero similarity, they set up a new psychic process every time, as evidenced by the fact that substitutions of 0 per cent. *S* are recognized as new always, without exception. On the other hand, impressions set up by stimuli of this character tend to blot out the memory of past experience to the extent of 39 per cent. I say blot out because my introspection notes show that even when my subjects had an image of the normal card of 0 per cent. *S* during the interval, the impression produced by the variable acted "like a flash of light," "like a blow between the eyes," and drove the idea of what the normal was completely out of mind. From this we may conclude that inasmuch as stimuli of absolute dissimilarity have but little association or recall value, a totally heterogeneous environment, by being detrimental to memory, would not yield continuity of thought processes. And this is as it should be, for what good would a memory do in a world where no two experiences were ever alike? Let me add, however, that there is nothing *a priori* about this "should be." It should be because it could not be otherwise, and that is all there is to it.

As we go along our scale of similarity we find that with increasing likeness of stimuli there goes a diminishing number of new experiences. Even when *S* has a value of 25 per cent., 8 per cent. of the stimuli fail to make a new impression on consciousness. And when the "physical world" becomes 55 per cent. similar our range of new experience drops to 67 per cent., when the environment becomes 85 per cent. homogeneous our consciousness contracts to the deplorable figure of 21 per cent. But perhaps one would think that the diminution of new experiences in an environment of increasing homogeneity would be compensated by a richer recall. My figures do not point to that. Stimuli of 25 per cent. *S* have as large an association (*R*) value as those of 75 per cent. *S*. That is to say, association by similarity seems to reach its maximum with a very small amount of similarity. And this I think is very fortunate, for it at once affords us the conditions where we can have the largest variety of experiences coupled with the richest memories of the past. In order to determine what the exact mixture of similarity and dissimilarity must be which should yield the best mental life, we need simply find the value of *S* that corresponds to the highest value of $D \times R$. Now the highest values of $D \times R$ are 85 and 82, corresponding to 25 per cent. and 35 per cent. *S*, respectively. Hence we may conclude that an environment which is a mixture of about 30 per cent. homogeneity and 70 per cent. heterogeneity is the most ideal environment for the continuity of consciousness.

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